FORM PTO-1390 REV. 5-93	US DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEYS DOCKET NUMBER P02,0024
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (if known, see 37 CFR 1.5) 10/070680

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/SE00/01662	**30 AUGUST 2000** (30-08-00)	**24 SEPTEMBER 1999** **(24-09-99)**

TITLE OF INVENTION

ISOLATION TRANSFORMER ARRANGEMENT

APPLICANT(S) FOR DO/EO/US

HARALD SORGER and THOMAS OHLSSON

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay.
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. ☒ A copy of International Application as filed (35 U.S.C. 371(c)(2)) - drawings attached.
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2) -

7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. §371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.

8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).

10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98; **(PTO 1449, Prior Art, Search Report).**

12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included. (Separate envelope)

13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.

14. ☒ A substitute specification, including red-lined version

15. ☐ A change of power of attorney and/or address letter.

16. ☒ Other items or information:

    a. ☒ Submission of Drawings for Publication
    b. ☒ Express Mail Label EL 843741094US dated March 7, 2002

U.S.APPLICATION NO. (if known, see 37 C.F.R. 1.5) 10/070680	INTERNATIONAL APPLICATION NO. PCT/SE00/01662	ATTORNEY'S DOCKET NUMBER P02,0024

17. ☒ The following fees are submitted:	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5): Search Report has been prepared by the EPO or JPO . . . . . $1040.00 International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) $890.00 No international preliminary examination fee paid to USPTO (37 C.F.R. 1.482) but international search fee paid to USPTO (37 C.F.R. 1.445(a)(2) . . . . . $740.00 Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2) paid to USPTO . . . . . $710.00 International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$1040.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)).	$	

Claims	Number Filed		Number Extra	Rate		
Total Claims	5	- 20 =	0	X $18.00	$	
Independent Claims	1	- 3 =	0	X $ 84.00	$	
Multiple Dependent Claims				$280.00 +	$	
				TOTAL OF ABOVE CALCULATIONS =	$1040.00	
Reduction by ½ for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 C.F.R. 1.9, 1.27, 1.28)					$	
				SUBTOTAL =	$1040.00	
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 *months* from the earliest claimed priority date (37 CFR 1.492(f)). +					$	
				TOTAL NATIONAL FEE =	$1040.00	
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). $40.00 per property +						
				TOTAL FEES ENCLOSED =	$1040.00	
				Amount to be refunded	$	
				charged	$	

a. ☒ A check in the amount of $1040.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ *in the amount of* $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **501519**. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Schiff Hardin & Waite
Patent Department
6600 Sears Tower
Chicago, Illinois 60606
Customer No. 26574

Steven H. Noll
SIGNATURE

Steven H. Noll
NAME

28,982 (Registration No.)

BOX PCT

IN THE UNITED STATES DESIGNATED OFFICE

OF THE UNITED STATES PATENT AND TRADEMARK OFFICE

UNDER THE PATENT COOPERATION TREATY-CHAPTER II

AMENDMENT "A" PRIOR TO ACTION AND SUBMISSION OF SUBSTITUTE SPECIFICATION

APPLICANTS: Sorger et al.

ATTORNEY DOCKET NO. P02,0024

INTERNATIONAL APPLICATION NO: PCT/SE00/01662

INTERNATIONAL FILING DATE: August 30, 2000

INVENTION: "ISOLATION TRANSFORMER ARRANGEMENT"

Assistant Commissioner for Patents

Washington, D.C. 20231

Sir:

Applicants herewith amend the above-referenced PCT application, and request entry of the Amendment prior to examination in the United States National Examination Phase.

IN THE SPECIFICATION:

Please enter the substitute specification submitted herewith pursuant to 37 C.F.R. §1.125(b). A marked-up copy showing all changes is also submitted herewith. The substitute specification does not add any new matter.

IN THE CLAIMS:

On page 8, in line 1, cancel "Claims" and substitute:

--**WE CLAIM AS OUR INVENTION:**-- therefor.

Cancel claims 1-5 and substitute the following claims therefor:

6. An isolation transformer arrangement comprising:

an isolation transformer having two magnetically coupled coils respectively forming a primary winding and a secondary winding;

one of said two coils being formed by at least one insulating substrate having a surface with a planar conductor run thereon;

another of said two coils being formed by a plurality of turns of an insulated wire conductor;

said insulating substrate comprising a multi-layer printed circuit board carrying two electrically separate circuits respectively connected to said primary winding and said secondary winding; and

said insulated wire conductor having insulation which provides a selected level of electrical isolation between said two circuits.

7. An isolation transformer arrangement as claimed in claim 6 wherein said isolation transformer comprises a hollow bobbin mounted on said surface of said printed circuit board, with said plurality of turns of said insulated wire conductor being wound on an exterior of said hollow bobbin, and wherein said printed circuit board has a through-hole therein and wherein said planar conductor run proceeds in coaxial paths around said through-hole, and further comprising a magnetic core element proceeding through said through-hole and said hollow bobbin to magnetically couple said primary and secondary windings.

8. An isolation transformer arrangement as claimed in claim 6 wherein said hollow bobbin with said plurality of turns of said insulated wire conductor thereon is releasably replaceable on said surface of said printed circuit board.

9. An isolation transformer arrangement as claimed in claim 6 wherein said planar conductor run forms said secondary winding.

10. An isolation transformer arrangement as claimed in claim 6 wherein one of said two circuits is adapted for connection to a patient sensor and is connected to said planar conductor run, and wherein another of said two circuits is adapted to receive a power supply line voltage and is connected to said plurality of turns of said insulated wire conductor.

IN THE ABSTRACT:

The Abstract has been amended as follows:

An isolation transformer arrangement has an isolation transformer having magnetically coupled primary and secondary windings, one of which is formed of at least one planar conductive run formed on an associated face of an insulating substrate of a printed circuit board and the other is formed of a number of turns of an insulated wire conductor. The printed circuit board also has one or more discreet electric components arranged in two electrically separate circuits each circuit connectable to a respective one of the primary and the secondary windings of the isolation transformer. The insulation of the wire conductor winding provides a desired level of electrical isolation between the circuits necessary for use in medical equipment.

REMARKS:

The present Amendment makes changes in the specification, claims and Abstract to conform the present PCT application to the requirements of United States patent practice. The cancellation of claims 1-5 in favor of the claims presented herein is solely because the amount of bracketing and underlining in the original claims necessary to conform those claims to the requirements of United States patent practice would have been unduly burdensome and confusing. No difference in claim language between the

original claims and the claims presented herein has been made for the purpose of distinguishing any claim over the teachings of the prior art of record, and accordingly no change in the claim language is considered by the Applicants as a surrender of any of the subject matter encompassed within the scope of original claims.

Early consideration of the present PCT application is respectfully requested.

Submitted by,

Stan A. Noll (Reg. 28,982)

SCHIFF, HARDIN & WAITE
CUSTOMER NO. 26574
Patent Department
6600 Sears Tower
233 South Wacker Drive
Chicago, Illinois 60606
Telephone: 312/258-5790
Attorneys for Applicants.

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE ABSTRACT

Please amend the Abstract as follows:

[Isolation Transformer Arrangement]

An isolation transformer arrangement [comprises] has an isolation transformer [(17)] having magnetically coupled primary [(25)] and secondary [(18) winding arrangement wherein] windings, one of [either the primary (25) or the secondary (18) winding] which is formed of at least one planar conductive [trace] run formed on an associated face of an insulating substrate [(29-32)] of a printed circuit board [(19)] and the other [(25)] is formed of a [plurality] number of turns of an insulated wire conductor. The printed circuit board [(19)] also has [also provided thereon] one or more discreet electric components arranged in two electrically separate circuits [(20;21)] each circuit connectable to a respective one of the primary [(2;25)] and the secondary [(3;18)] windings of the isolation transformer [(1;17) in which the]. The insulation of the wire conductor winding [(25) is adapted to provide] provides a desired level of electrical isolation between the circuits [(20;21)] necessary for use in medical equipment.

[Fig. 3]

SUBSTITUTE SPECIFICATION

SPECIFICATION

TITLE

"ISOLATION TRANSFORMER ARRANGEMENT"

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an isolation transformer arrangement and in particular to an arrangement suitable for providing an isolation barrier in medical equipment.

Description of the Prior Art

Many types of medical equipment include sensors which are in contact with a patient. Although these sensors operate at low voltage and current levels that do not present a shock hazard to the patient that hazard can occur if an electrical short circuit occurs within the equipment or if other equipment connected to the patient develops a fault and the relatively high voltage and current levels from an external power supply line are supplied to the sensors contacting the patient.

For these reason regulatory authorities of many countries, such as for example the F.D.A. in the USA which requires compliance with IEC 60606-1, specify that medical equipment must be designed with an isolation barrier between circuits containing patient connections and circuits connected to power supply line voltages. Such isolation barriers must isolate against several kilovolts AC with a leakage current of only several microamperes when the supply line voltage is applied across the isolation barrier. Typically, suitable isolation barriers are formed using isolation transformers, usually mounted on a printed circuit board (PCB) containing the circuits to be isolated. Generally, one of the two circuits between which an isolation barrier is required is electrically connected to the primary transformer winding or windings and the other circuit to the secondary transformer winding or windings.

One known type of isolation transformer is a "bobbin-type" isolation transformer which has a hollow plastic former or bobbin about which wires are wound to form the primary and the secondary windings and through which a ferrite core piece passes. The primary and secondary windings may be wound concentrically, one on top of the other, or may be displaced from one another along the core to increase the so called "creepage distance". The necessary isolation may be achieved by sheathing the wire of the two sets of windings in a suitable insulating material. This provides a transformer which is relatively inexpensive to produce and one in which faulty windings can be readily replaced.

However, the isolation achieved in this type of transformer is largely due to the separation and insulation between wires and the windings which mitigates against reducing the size of the transformer for mounting on the PCB. Size of the transformer can become a major issue since the medical device typically needs to accommodate several PCBs, one or some of which may have mounted thereon isolation transformers, in as small a volume as possible. Moreover, complicated tapping arrangements for the windings are difficult to achieve in wire wound transformers and often lead to a high failure rate and a consequent increased unit cost.

Low-profile planar transformers are also well known as isolation barriers. In such transformers the primary and secondary windings are each formed by electrically conducting runs, usually on an insulating planar surface such as a surface of a PCB, for example a multi-layer PCB, and arranged so that successive runs are separated by an insulating PCB layer to provide at least part of the necessary isolation. The layer or layers that constitute each of the windings are then usually magnetically coupled by means of an inductive core member. Forming the windings on a PCB also provides an increased ease of tapping selected conducting traces to provide a selectable transformer output voltage as compared to tapping selected

windings of a wire wound transformer. This also allows complex tapping arrangements to be constructed relatively simply and consistently.

However the bonding of the PCB layers is usually done by gluing which also contributes to the isolation but can lead to uncontrolled variations in the dielectric properties of the inter-trace insulation, for example through the uncontrolled formation of air bubbles within the glue as it is applied. This is of particular concern for the insulation between the primary and the secondary windings as it may adversely effect the isolation provided by the transformer This leads to the necessity for increased quality control and hence higher unit costs.

It is also known from PCT Application WO 99/31683 to provide a "hybrid" low profile transformer power supply formed by a flat winding primary coil magnetically coupled to a secondary coil having a winding pattern deposited on a substrate such as a PCB. The transformer is designed specifically for mounting outside a periphery of a PCB which carries circuitry to be powered from the transformer.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an isolation transformer of relatively small size in which the isolation characteristics can be readily controllable and which can be integrated with a PCB carrying circuitry to be isolated.

The above object is achieved in accordance with the principles of the present invention in an isolation transformer arrangement having an isolation transformer with magnetically coupled primary and secondary windings, one of which is formed by at least one insulating substrate with a planar conductor run on a surface thereof, and the other of which is formed by a number of turns of an insulated wire conductor, and wherein the insulating substrate is a multi-layer printed circuit board also carrying two electrically separate circuits respectively connectable to the primary and secondary

windings, and wherein the insulation of the wire conductor provides a desired level of electrical isolation between the two circuits.

By providing one winding as a planar conductive trace on the PCB board carrying circuitry to be isolated by the transformer a reduction in size and an ease of tapping as compared with an all wire transformer is achieved and by providing an insulated wire winding substantially all of the electrical isolation necessary for medical use can be achieved by a suitable tailoring of that insulation in a manner well known in the art. Moreover, the isolation can be tested before the wire is turned to provide the transformer winding, thereby reducing the possibility of the completed transformer being rejected during quality control.

Usefully the wire may be turned about a hollow bobbin similar to the known bobbin type transformer arrangement or other former, such as a leg of an E-core ferrite element, to provide for ease of collocation of the primary and secondary windings into the final transformer. The bobbin (or former) and the planar windings may be releasably replaceable which has the advantage that, since the isolation is provided by the insulated wire winding poor isolation caused by faulty insulation in an assembled transformer can be easily remedied without replacing the entire transformer and hence the entire circuitry contained on the PCB board.

DESCRIPTION OF THE DRAWINGS

Fig. 1 shows details of an embodiment of the isolation transformer arrangement according to the present invention.

Fig. 2 shows an example of a planar conductive trace used as a component of a winding of the transformer of Fig. 1

Fig. 3 shows an isolation transformer arrangement according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Fig. 1 details of an isolation transformer arrangement according to the present invention are shown. An isolation transformer 1 has

a wire winding 2; a planar winding 3 and a magnetic core element comprising a conventional co-operating E-core 4 and I-core 5 arrangement. Spring clips 6,7 are provided to hold the cores 4,5 together in the assembled transformer.

The wire winding 2 has a number of turns helically wound about a central leg 8 of the E-core 4. The wire winding 2 is formed from a wire 9 within an insulating sheath 10 of sufficient thickness to provide an isolation between the wire 9 and the leg 8 and between the winding 2 and the planar winding 3 to withstand an applied voltage of 1500 V (RMS) and a 5000V defibrillation pulse which may be applied to a patient in cardiac arrest in an attempt to re-start or stabilize the heart output.

The planar winding 3 has a number of printed circuit boards (PCBs) 11a, 11b and 11c bonded to form a stacked arrangement locatable about the central leg 8 of the E-core 4 the PCBs 11a, 11b and 11c form a part of a PCB carrying electrical circuits to be isolated by the transformer 1 (see circuits 20,21 of Fig. 3). Thus the central leg 8 magnetically couples the two windings 2, 3 in the assembled transformer 1. Each circuit board 11a, 11b, 11c is, on at least one of its planar faces, is provided with a conducting run (not shown). These runs together form the conventionally formed planar transformer winding 3. Since the isolation is provided by the insulation 10 about the wire winding 2 then the isolation demand between any of the traces, whether on the same or another layer, is no higher than it would be between any run on a conventional printed circuit board.

Considering now Fig. 2 an exemplary printed circuit board (here for example 11a) of the planar winding 3 is shown in more detail. A planar conductive run formed by two tracks 12a, 12b has been formed on one surface 13 of the printed circuit board 11a in a conventional manner. These tracks 12a,12b are arranged concentrically with a hole 14 through the board 11a through which the central leg 8 of the E-core 4 (Fig. 1) passes. Through-holes 15a, 15b, 15c are also provided in the board 11a and are conductively plated to allow the electrical connection of runs on the other

boards 11b, 11c which form the planar winding 3. Additional plated through-holes 16a, 16b, 16c, 16d are provided to allow electrical connections to be established between the planar winding 3 and external of the transformer 1 (for example to permit the connection of different combinations of tracks to different circuits which are also carried by the multi-layered PCB board 11a, 11b, 11c).

Fig. 3 also shows the arrangement according to the present invention. A planar winding 18 of the transformer 17 is shown together with circuits 20, 21 to be isolated from one another by the transformer 17 as integral parts of a multi-layer printed circuit board 19. The transformer 17 further has a first E-core 22 configured with a central leg 23 which passes through a plastic bobbin 24 about which is wound an insulated wire winding 25. Although the use of a bobbin 24 is preferred for ease of assembly it is possible to use a wire winding 2 which is spiraled directly about a central leg 8 of the core element 4, as illustrated in Fig. 1.

The winding 25 is insulated sufficiently to provide the substantially all of the desired isolation between the two windings 25,18 of the transformer 17. Contact legs 26 project from the base of the bobbin 24 and are connected to opposite ends of the wire winding 25 to provide for electrical connection of the winding 25 external of the transformer 17. Different to the transformer 1 of Fig.1, a second E-core 27 (as opposed to the I-core 5 of Fig. 1) is provided to complete a magnetic flux path coupling the windings 18,25.

The circuit board 19 is here shown with 5 layers 28-32. The first layer 28 has an upper surface 33 on which the two circuits 20,21 to be isolated are realized. Three through holes 34, 35, 36 are provided and are dimensioned to permit passage through the board 19 of the legs of the E-cores 22, 27. Two plated recesses 37, 38 are provided in the upper surface 33 to receive the contact legs 26 and are electrically connected to the circuit 21, which is typically connected to receive mains power. Three plated holes 39 pass from the upper surface 33 to the planar winding 18 to provide electrical

contact to different numbers of turns of the planar winding 18 and are electrically connected to the other circuit 20, which is typically connected to patient sensors (not shown). All of these electrical connections 34-39 can be readily arranged on the upper surface 33 of the multi-layer printed circuit board 19 to provide the correct creepage distances to meet the appropriate national or international regulatory requirements for the electrical isolation of medical equipment.

As illustrated in Fig.3 the planar winding 18 is formed by the layers 29-31, each having on their upper surfaces (relative to the upper surface 27) a conductive track, for example similar to the tracks 12a, 12b shown in Fig. 2, to form the planar conductive winding 18 in the region shown by the broken lines. With this arrangement a degree of isolation between the wire winding 25 and the planar winding 18 is also provided by the thickness of insulating material in the layer 28.

Although modifications and changes may be suggested by those skilled in the art, it is the intention of the inventors to embody within the patent warranted hereon all changes and modifications as reasonably and properly come within the scope of their contribution to the art.

Description

Isolation Transformer Arrangement

The present invention relates to an isolation transformer arrangement and in particular to an arrangement suitable for providing an isolation barrier in medical equipment.

Many types of medical equipment include sensors which are in contact with a patient. Although these sensors operate at low voltage and current levels that do not present a shock hazard to the patient that hazard can occur if an electrical short circuit occurs within the equipment or if other equipment connected to the patient develops a fault and the relatively high voltage and current levels from an external power supply line is supplied to the sensors contacting the patient.

For these reason regulatory authorities of many countries, such as for example the F.D.A. in the USA which requires compliance with IEC 60606-1, specify that medical equipment must be designed with an isolation barrier between circuits containing patient connections and circuits connected to power supply line voltages which can isolate against several kilovolts AC with a leakage current of only several microamperes when the supply line voltage is applied across the isolation barrier. Typically, suitable isolation barriers are formed using isolation transformers, usually mounted on a printed circuit board (PCB) containing the circuits to be isolated. Generally, one of the two circuits between which an isolation barrier is required is electrically connected to the primary transformer winding or windings and the other circuit to the secondary transformer winding or windings.

One known type of isolation transformer is a "bobbin-type" isolation transformer which comprises a hollow plastic former or bobbin about which wires are wound to form the primary and the secondary windings and through which a ferrite core piece

passes. The wire primary and secondary windings may be wound concentrically, one on top of the other, or may be displaced from one another along the core to increase the so called "creepage distance". The necessary isolation may be achieved by sheathing the wire of the two sets of windings in a suitable insulating material. This provides a transformer which is relatively inexpensive to produce and one in which faulty windings can be readily replaced.

However, the isolation in this type of transformer is largely an issue of the separation and insulation between wires and the windings which mitigates against minimising the size of the transformer for mounting on the PCB. Size of the transformer can become a major issue since the medical device typically needs to accommodate several PCBs, one or some of which may have mounted thereon isolation transformers, in a small a volume as possible. Moreover, complicated tapping arrangements for the windings are difficult to achieve in wire wound transformers and often lead to a high failure rate and a consequent increased unit cost.

Low-profile planar transformers are also well known as isolation barriers. In such transformers the primary and secondary windings are each made as electrically conducting traces, usually on an insulating planar surface such as a surface of a PCB, for example a multi-layer PCB, and arranged so that successive traces are separated by an insulating PCB layer to provide at least part of the necessary isolation. The layer or layers that constitute each of the windings are then usually magnetically coupled by means of an inductive core member. Forming the windings on a PCB also provides an increased ease of tapping selected conducting traces to provide a selectable transformer output voltage as compared to tapping selected windings of a wire wound transformer. This also allows complex tapping arrangements to be constructed relatively simply and consistently.

However the bonding of the PCB layers is usually done by gluing which also contributes to the isolation but can lead to uncontrolled variations in the dielectric properties of the inter-trace insulation, for example through the uncontrolled formation of air bubbles within the glue as it is applied. This is of particular concern for the insulation between the primary and the secondary windings as it may adversely effect the isolation provided by the transformer This leads to the necessity for increased quality control and hence higher unit costs.

It is also known from WO 99/31683 to provide a "hybrid" low profile transformer power supply comprising a flat winding primary coil magnetically coupled to a secondary coil comprising a winding pattern deposited on a substrate such as a PCB. The transformer is designed specifically for mounting outside a periphery of a PCB which carries circuitry to be powered from the transformer.

It is an aim of the present invention to provide an isolation transformer of relatively small size in which the isolation characteristics can be readily controllable and which can be integrated with a PCB carrying circuitry to be isolated.

Accordingly the present invention provides an isolation transformer arrangement as described in and characterised by the present Claim 1. By providing one winding as a planar conductive trace on the PCB board carrying circuitry to be isolated by the transformer a reduction in size and an ease of tapping as compared with an all wire transformer is achieved and by providing an insulated wire winding substantially all of the electrical isolation necessary for medical use can be achieved by a suitable tailoring of that insulation in a manner well known in the art. Moreover, the isolation can be tested before the wire is turned to provide the transformer winding, thereby reducing the possibility of

the completed transformer being rejected during quality control.

Usefully the wire may be turned about a hollow bobbin similar to the known bobbin type transformer arrangement or other former, such as a leg of an E-core ferrite element, to provide for ease of collocation of the primary and secondary windings into the final transformer. The bobbin (or former) and the planar windings may be releasably collocated which has the advantage that since the isolation is provided by the insulated wire winding poor isolation caused by faulty insulation in an assembled transformer can be easily remedied without replacing the entire transformer and hence the entire circuitry contained on the PCB board.

Embodiments of the present invention will now be described with reference to drawings of the accompanying Figures of which:

Fig. 1 shows details of an embodiment of the isolation transformer arrangement according to the present invention.

Fig. 2 shows an example of a planar conductive trace used as a component of a winding of the transformer of Fig. 1

Fig. 3 shows an isolation transformer arrangement according to the present invention.

Referring now to Fig. 1 details of an isolation transformer arrangement according to the present invention are shown. An isolation transformer 1 comprises a wire winding 2; a planar winding 3 and a magnetic core element comprising a conventional co-operating E-core 4 and I-core 5 arrangement. Spring clips 6,7 are provided to hold the cores 4,5 together in the assembled transformer.

The wire winding 2 comprises a plurality of turns spirally wound about a central leg 8 of the E-core 4. The wire winding 2 is formed from a wire 9 within an insulating sheath 10 of sufficient thickness to provide an isolation between the wire 9 and the leg 8 and between the winding 2 and the planar winding 3 to withstand an applied voltage of 1500 V (RMS) and a 5000V defibrillation pulse which may be applied to a patient in cardiac arrest in an attempt to re-start or stabilise the heart output.

The planar winding 3 comprises a plurality 11a, 11b, 11c of printed circuit boards (PCBs) bonded to form a stacked arrangement locatable about the central leg 8 of the E-core 4, and which PCBs forms part of a PCB carry electrical circuits to be isolated by the transformer 1 (see circuits 20,21 of Fig. 3). Thus the central leg 8 magnetically couples the two windings 2, 3 in the assembled transformer 1. Each circuit board 11a, 11b, 11c is, on at least one of its planar faces, provided with a conducting trace (not shown). These traces together comprise the conventionally formed planar transformer winding 3. Since the isolation is provided by the insulation 10 about the wire winding 2 then the isolation demand between any of the traces, whether on the same or another layer, is no higher than it would be between any trace on a conventional printed circuit board.

Considering now Fig. 2 an exemplary printed circuit board (here for example 11a) of the planar winding 3 is shown in more detail. A planar conductive trace comprising two tracks 12a, 12b has been formed on one surface 13 of the printed circuit board 11a in a conventional manner. These tracks 12a,12b are arranged concentrically with a hole 14 through the board 11a through which the central leg 8 of the E-core 4 (Fig. 1) passes. Through-holes 15a, 15b, 15c are also provided in the board 11a and are conductively plated to allow the electrical connection of traces on the other boards 11b, 11c which comprise the planar winding 3. Additional

plated through-holes 16a, 16b, 16c, 16d are provided to allow electrical connections to be established between the planar winding 3 and external of the transformer 1 (for example to permit the connection of different combinations of tracks to different circuits which are also carried by the multi-layered PCB board 11a, 11b, 11c).

Considering now Fig. 3 in which the arrangement according to the present invention is shown. A planar winding 18 of the transformer 17 is shown together with circuits 20, 21 to be isolated from one another by the transformer 17 as integral parts of a multi-layer printed circuit board 19. The transformer 17 further comprises a first E-core 22 configured with a central leg 23 which passes through a plastic bobbin 24 about which is wound an insulated wire winding 25. Although the use of a bobbin 24 is preferred for ease of assembly it is possible to use a wire winding 2 which is spiralled directly about a central leg 8 of the core element 4, as illustrated in Fig. 1.

The winding 25 is insulated sufficiently to provide the substantially all of the desired isolation between the two windings 25,18 of the transformer 17. Contact legs 26 project from the base of the bobbin 24 and are connected to opposite ends of the wire winding 25 to provide for electrical connection of the winding 25 external of the transformer 17. Different to the transformer 1 of Fig.1, a second E-core 27 (as opposed to the I-core 5 of Fig. 1) is provided to complete a magnetic flux path coupling the windings 18,25.

The circuit board 19 is here shown to comprise 5 layers 28-32. The first layer 28 has an upper surface 33 on which the two circuits 20,21 to be isolated are realised. Three through holes 34,35,36 are provided and are dimensioned to permit passage through the board 19 of the legs of the E-cores 22,27. Two plated recesses 37, 38 are provided in the upper surface 33 to receive the contact legs 26 and are

electrically connected to the circuit 21, which is typically connected to receive mains power. Three plated holes 39 pass from the upper surface 33 to the planar winding 18 to provide electrical contact to different numbers of turns of the planar winding 18 and are electrically connected to the other circuit 20, which is typically connected to patient sensors (not shown). All of these electrical connections 34-39 can be readily arranged on the upper surface 33 of the multi-layer printed circuit board 19 to provide the correct creepage distances to meet the appropriate national or international regulatory requirements for the electrical isolation of medical equipment.

As illustrated in Fig.3 the planar winding 18 is realised in the layers 29-31, each have on their upper surfaces (relative to the upper surface 27) a conductive trace, for example similar to the trace 12a, 12b shown in Fig. 2, to form the planar conductive winding 18 in the region shown by the broken lines. With this arrangement a degree of isolation between the wire winding 25 and the planar winding 18 is also provided by the thickness of insulating material in the layer 28.

Claims

1. An isolation transformer arrangement comprising an isolation transformer (1;17) having magnetically coupled primary and secondary winding arrangement (2,3;18,25 wherein one of either the primary (2;25) or the secondary (3;18) winding is formed of at least one insulating substrate (11a,b,c; 29-32) having on a surface thereof a planar conductive trace (12a,12b) and the other (2;25) is formed of a plurality of turns of an insulated wire conductor (9) characterised in that the insulating substrate comprises a multi-layer printed circuit board (19) having also provided thereon one or more discreet electric components arranged in two electrically separate circuits (20;21) with each circuit connectable to a respective one of the primary (2;25) and the secondary (3;18) windings of the isolation transformer (1;17); and in that the insulation (10) of the wire conductor (9) is adapted to provide a desired level of electrical isolation between the circuits (20;21).

2. An isolation transformer arrangement as claimed in Claim 1 characterised in that the wire winding (25) is provided spiralled about an outer surface of a hollow bobbin (24) locatable on a surface (33) of the printed circuit board (19); the planar trace winding (18) is coaxially arranged about a hole (35) through the printed circuit board (19); and in that there is further provided a magnetic core element (22,27) positionable through the hole (35) and the hollow bobbin (24) to magnetically couple the windings (18,25).

3. An isolation transformer arrangement as claimed in Claim 1 or Claim 2 characterised in that the primary and the secondary windings (2,3;25,18) are releasably collocatable.

4. An isolation transformer arrangement (1;17) as claimed in any preceding claim characterised in that the

planar conductive trace winding (3;18) is the secondary winding.

5. An isolation transformer arrangement as claimed in any preceding claim characterised in that a one (20) of the two circuits (20,21) is adapted for connection to patient sensors and is connected to the winding (18) formed of the planar conductive trace and in that the other of the two circuits (21,20) is adapted to receive power supply line voltages and is connected to the wire winding (25).

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 March 2001 (29.03.2001)

PCT

(10) International Publication Number
WO 01/22445 A1

(51) International Patent Classification[7]: H01F 27/28

(21) International Application Number: PCT/SE00/01662

(22) International Filing Date: 30 August 2000 (30.08.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
9903466-2 24 September 1999 (24.09.1999) SE

(71) Applicant *(for all designated States except US)*: **SIEMENS-ELEMA AB** [SE/SE]; S-171 95 Solna (SE).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **SORGER, Harald** [DE/DE]; Balanstrasse 82, 81541 München (DE). **OHLSSON, Thomas** [SE/SE]; Backlöksvägen 53, S-165 77 Hässelby (SE).

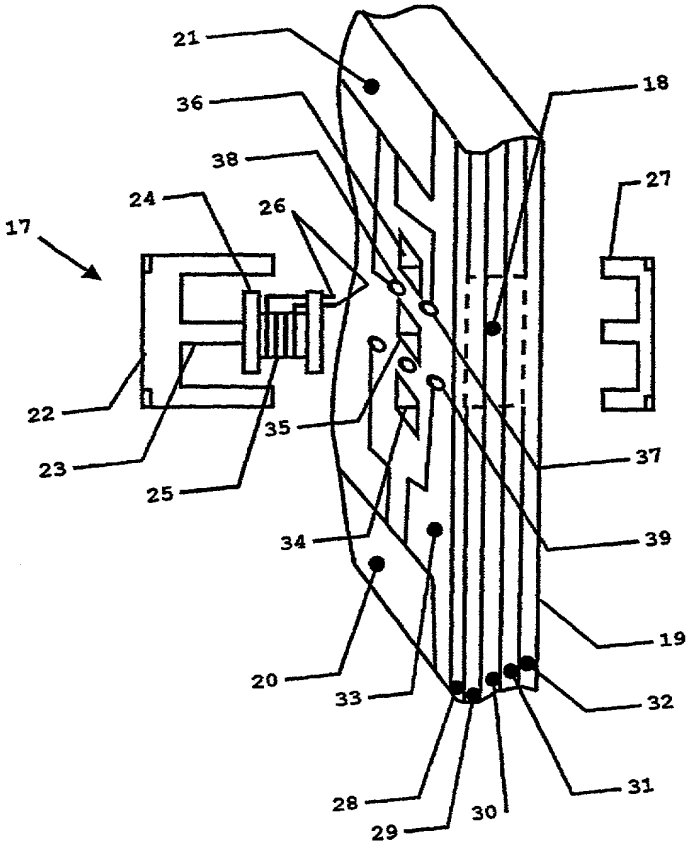
(74) Common Representative: **SIEMENS-ELEMA AB**; Att: Patentbyrå Siemens, S-171 95 Solna (SE).

(81) Designated States *(national)*: DE, JP, US.

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: ISOLATION TRANSFORMER ARRANGEMENT



(57) Abstract: An isolation transformer arrangement comprises an isolation transformer (17) having magnetically coupled primary (25) and secondary (18) winding arrangement wherein one of either the primary (25) or the secondary (18) winding is formed of at least one planar conductive trace formed on an associated face of an insulating substrate (29-32) of a printed circuit board (19) and the other (25) is formed of a plurality of turns of an insulated wire conductor. The printed circuit board (19) has also provided thereon one or more discreet electric components arranged in two electrically separate circuits (20; 21) each circuit connectable to a respective one of the primary (2; 25) and the secondary (3; 18) windings of the isolation transformer (1; 17) in which the insulation of the wire conductor winding (25) is adapted to provide a desired level of electrical isolation between the circuits (20; 21) necessary for use in medical equipment.

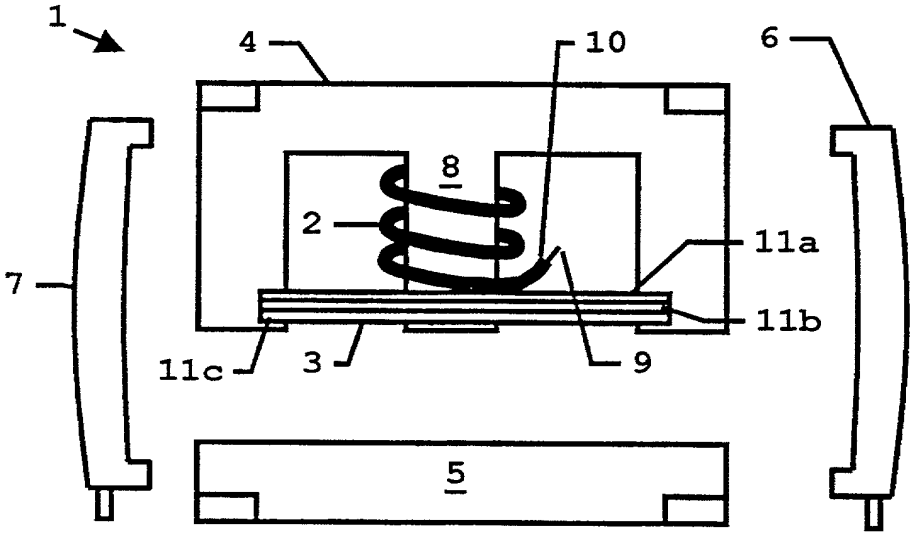


FIG. 1

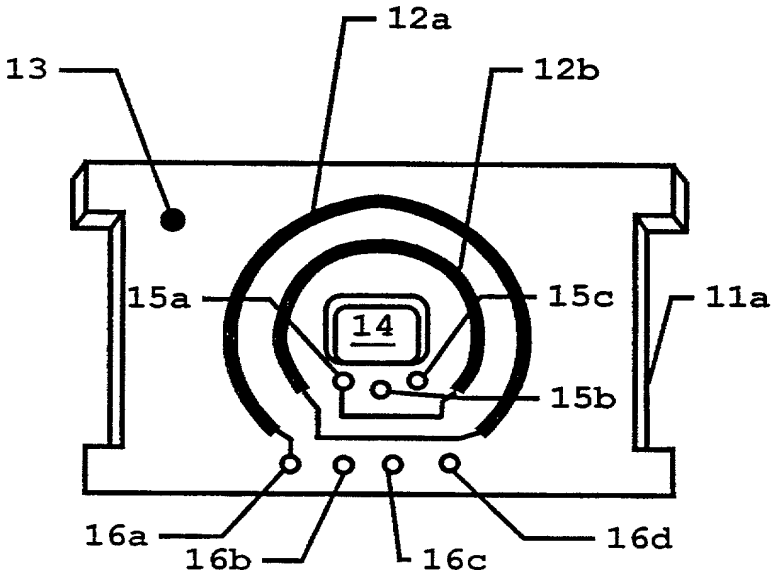


FIG.2

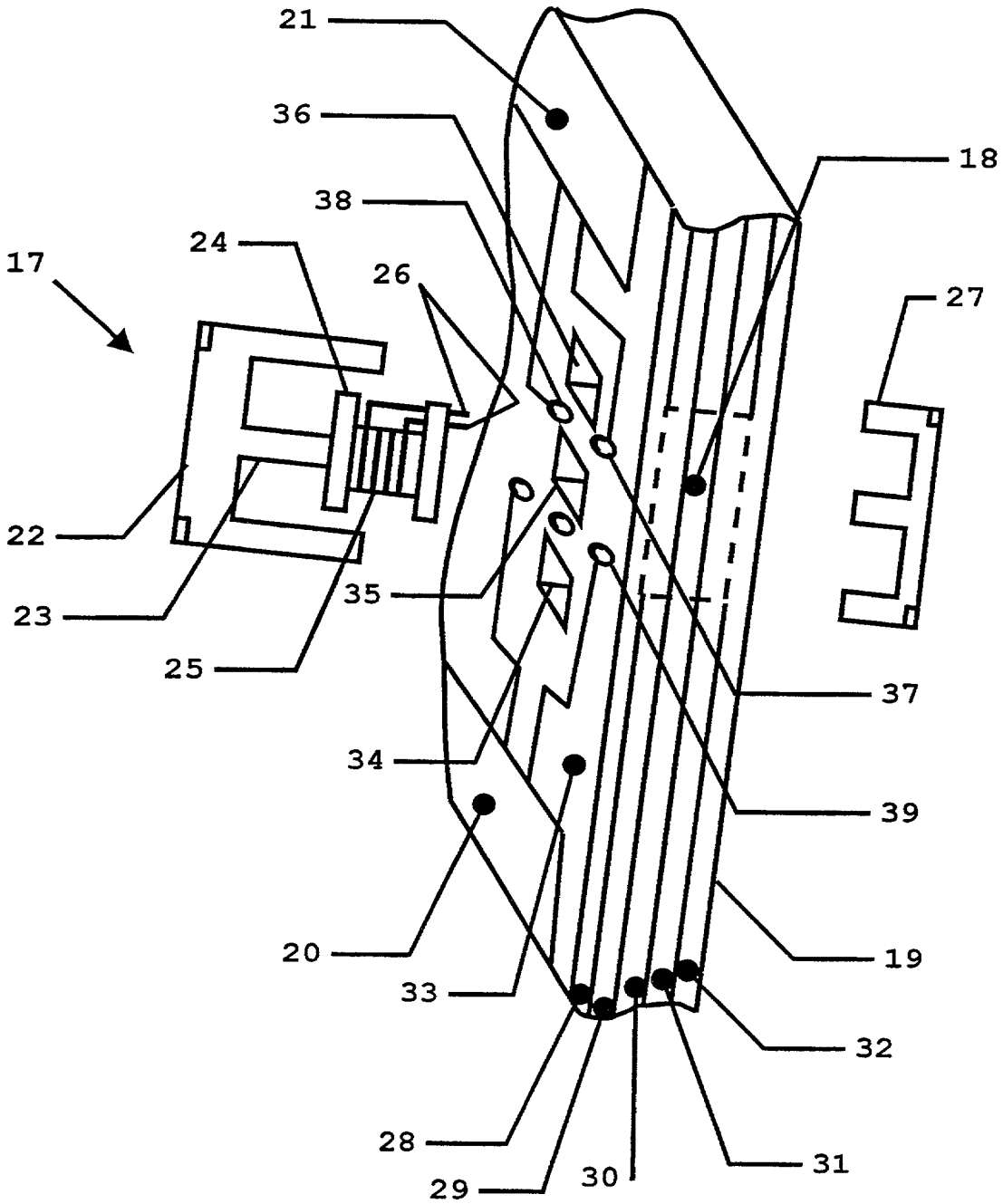


FIG. 3

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY (Includes Reference to PCT International Applications)	ATTORNEY'S DOCKET NUMBER **P02,0024**

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,
I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

"ISOLATION TRANSFORMER ARRANGEMENT"

the specification of which (check only one item below):

□ is attached hereto.

□ was filed as United States application
Serial No. _____

on _____,

and was amended

on _____(if applicable).

■ was filed as PCT international application

Number PCT/SE00/01662

on August 30, 2000,

and was amended under PCT Article 19

on _____(if applicable).

I hereby state that I have reviewed and understand the contest of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

COUNTRY (if PCT indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119
SWEDEN	9903466-2	24.09.1999	■ YES □ NO
			□ YES □ NO
			□ YES □ NO
			□ YES □ NO
			□ YES □ NO

[redacted]d Declaration For Patent Application and Power of Attorney (Continued)
[redacted]udes Reference to PCT International Applications)

ATTORNEY'S DOCKET NO.
P02,0024

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject mater of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, Untied States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:

U.S. APPLICATIONS		STATUS (Check one)		
U.S. APPLICATION NUMBER	U.S. FILING DATE	PATENTED	PENDING	ABANDONED

PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (if any)			

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected herewith.

And I hereby appoint all Attorneys identified by the United States Patent & Trademark Office Customer Number 26574, who are all members of the firm of Schiff, Hardin & Waite.

Send Correspondence to: SCHIFF, HARDIN & WAITE
Patent Department
6600 Floor Sears Tower, Chicago, Illinois 60606
Customer Number 26574

Direct Telephone Calls to:
312/258-5790

201	FULL NAME OF INVENTOR	FAMILY NAME **SORGER**	FIRST GIVEN NAME **HARALD**	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Munich DEX	STATE OR FOREIGN COUNTRY Germany	COUNTRY OF CITIZENSHIP Germany
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Balanstrasse 82	CITY Munich	STATE & ZIP CODE/COUNTRY D-81541 Munich, Germany
202	FULL NAME OF INVENTOR	FAMILY NAME **OHLSSON**	FIRST GIVEN NAME **THOMAS**	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY Hässelby SEX	STATE OR FOREIGN COUNTRY Sweden	COUNTRY OF CITIZENSHIP Sweden
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Backlöksvägen 53	CITY Hässelby	STATE & ZIP CODE/COUNTRY S-165 77 Hässelby, Sweden
203	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
DATE 2002-02-10	DATE 2002-02-05	DATE